

# ROOT-based Event Display for LBNE-35t

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# Updates Since Doc-8715

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- Renamed the project to RED35
  - <https://github.com/czczc/RED35>
- Updated the geometry to use lbne35tapa\_v3.gdml
- Updated to work with LarSoft v4\_01
  - renamed the Module to CTree35t
  - currently in a feature brach feature/chaoz\_ctree
- Added more information to the event display
  - wire signals (raw, calibrated, hits)
  - MC tracks (2d, 3d)
  - Reco tracks (3d)

# Components of RED35

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- There are basically **three components** in RED35
  - **A converter** to convert sim/reco files to a event tree for offline reading  
(*dependent on LarSoft*)
    - `git flow feature pull origin chaoz_ctree`
    - `lar -c ctree35t.fcl [sim/reco root file]`
  - **A 3D Event Display** (*independent of LarSoft*)
    - based on the ROOT module EVE (invented for the ALICE experiment)  
[https://root.cern.ch/root/html/doc/GRAF3D\\_EVE\\_Index.html](https://root.cern.ch/root/html/doc/GRAF3D_EVE_Index.html)
  - **A 2D Event Display** (*independent of LarSoft*)
    - based on the ROOT GUI widgets  
[https://root.cern.ch/root/html/GUI\\_GUI\\_Index.html](https://root.cern.ch/root/html/GUI_GUI_Index.html)
- How to install and run (on your own computer)  
<https://github.com/czczc/RED35>

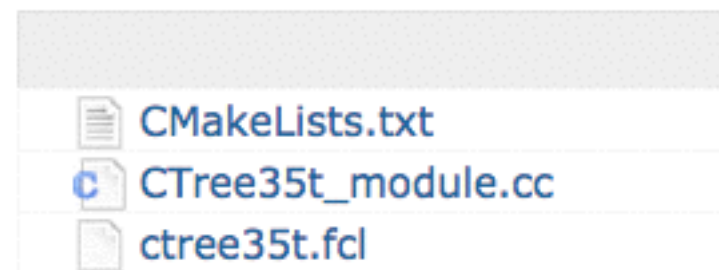
# The Converter

```
lar -c ctree35t.fcl [sim/reco root file]
```

- Currently the following information are stored as branches in the converted TTree

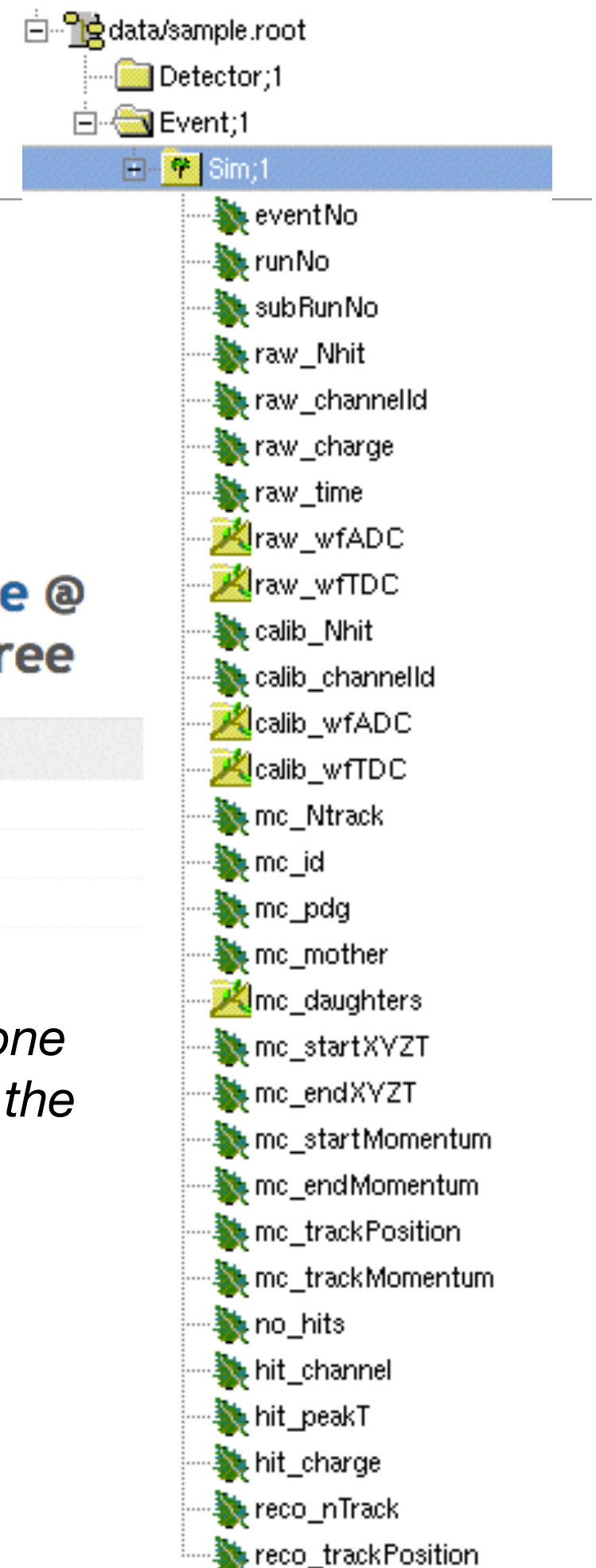
- MC particles
  - tracks
  - mother/daughter relations
- raw wire signals
- calibrated wire signals
- hits found on each wire
- 3d reco tracks

**root / lbne / CTree @  
feature/chaoz\_ctree**

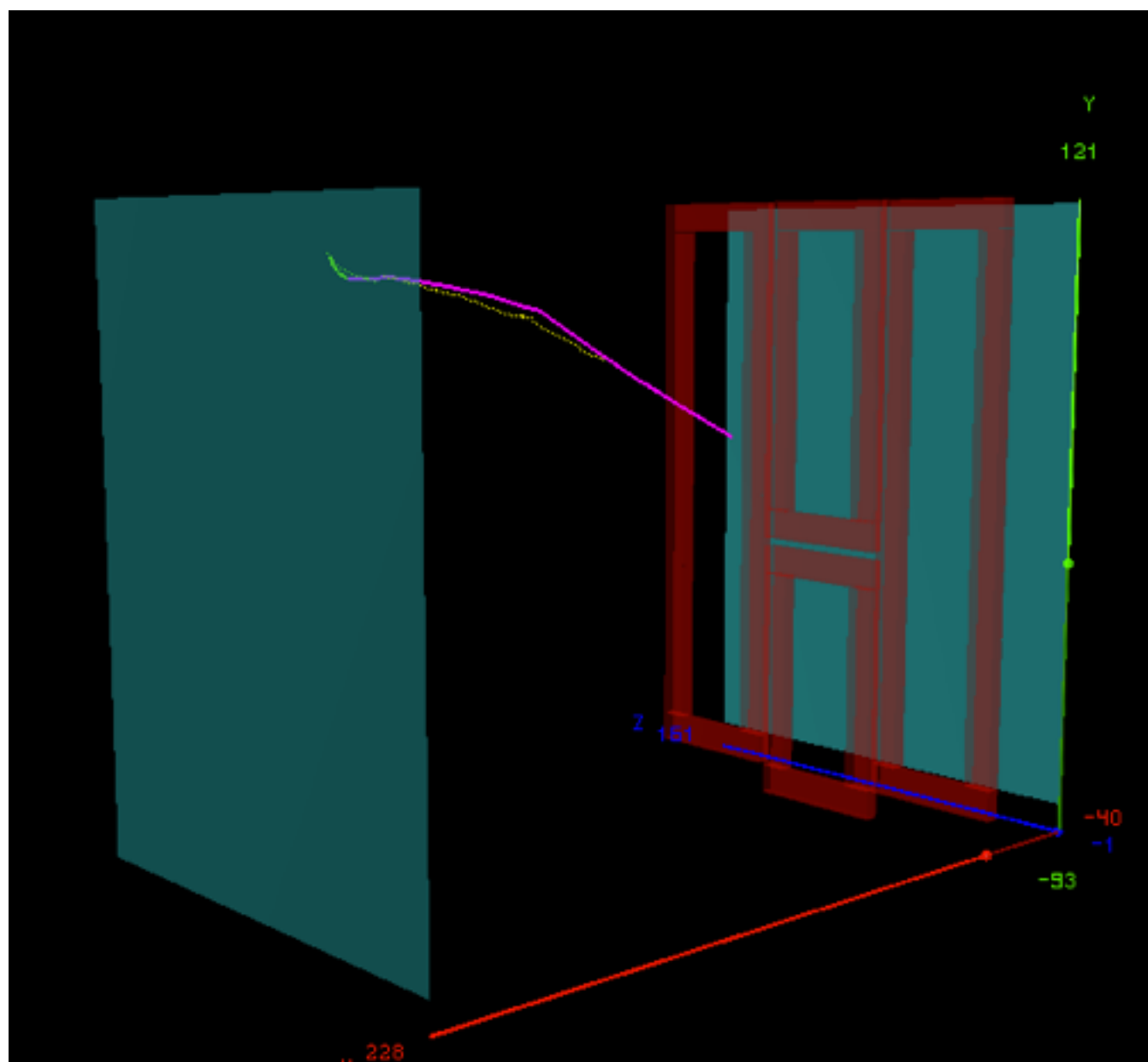
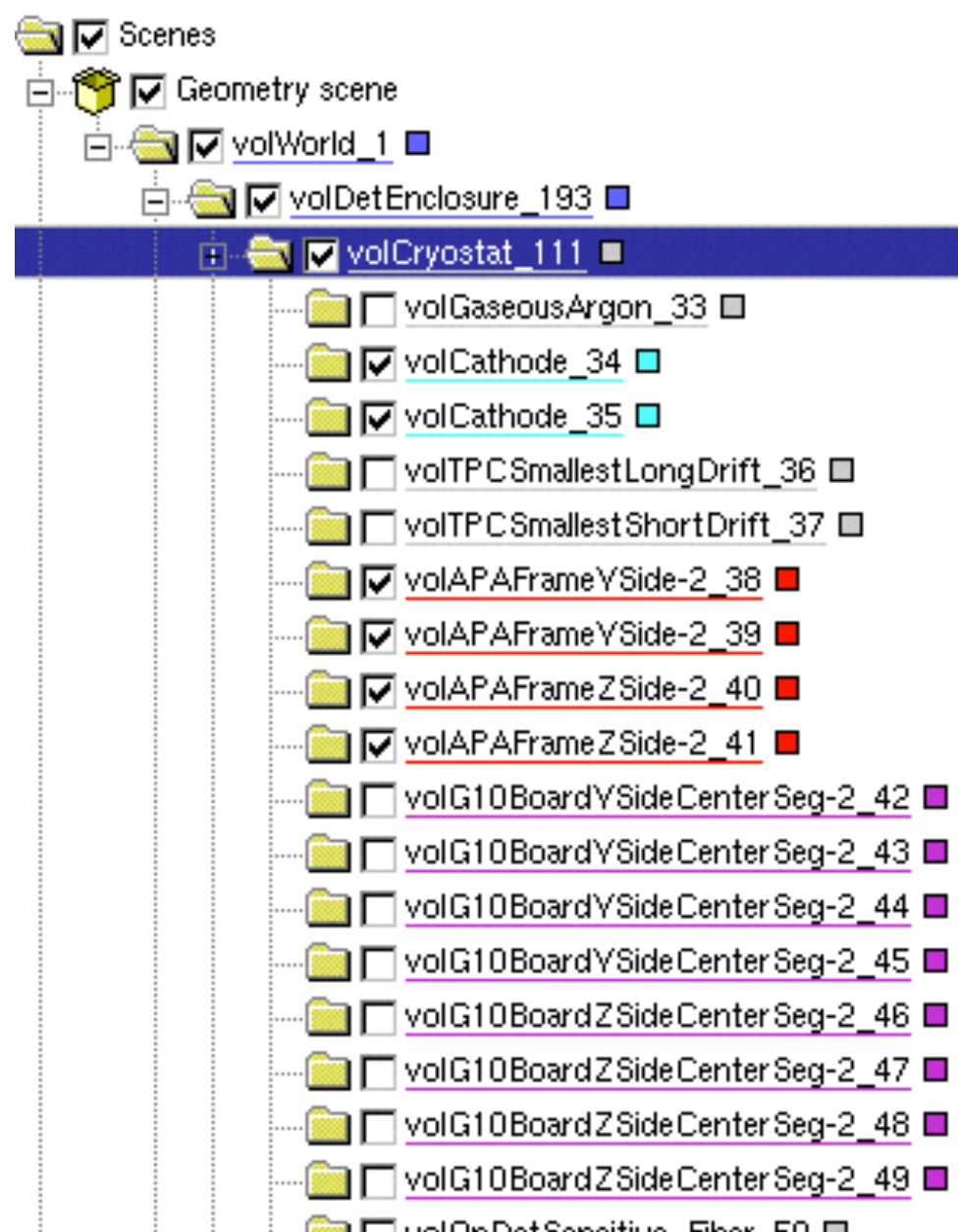


*currently only store one  
algorithm (specify in the  
.fcl file)*

- Currently a factor of ~10 — 50 reduction in data size (can be optimized in the future)



# 3D Event Display



- By default turned off many detector elements for visual clarity
- Can turn on DEs by hand (or can provide options in the future)

2D projections (next slide)

event navigation

MC tracks  
in solid  
lines

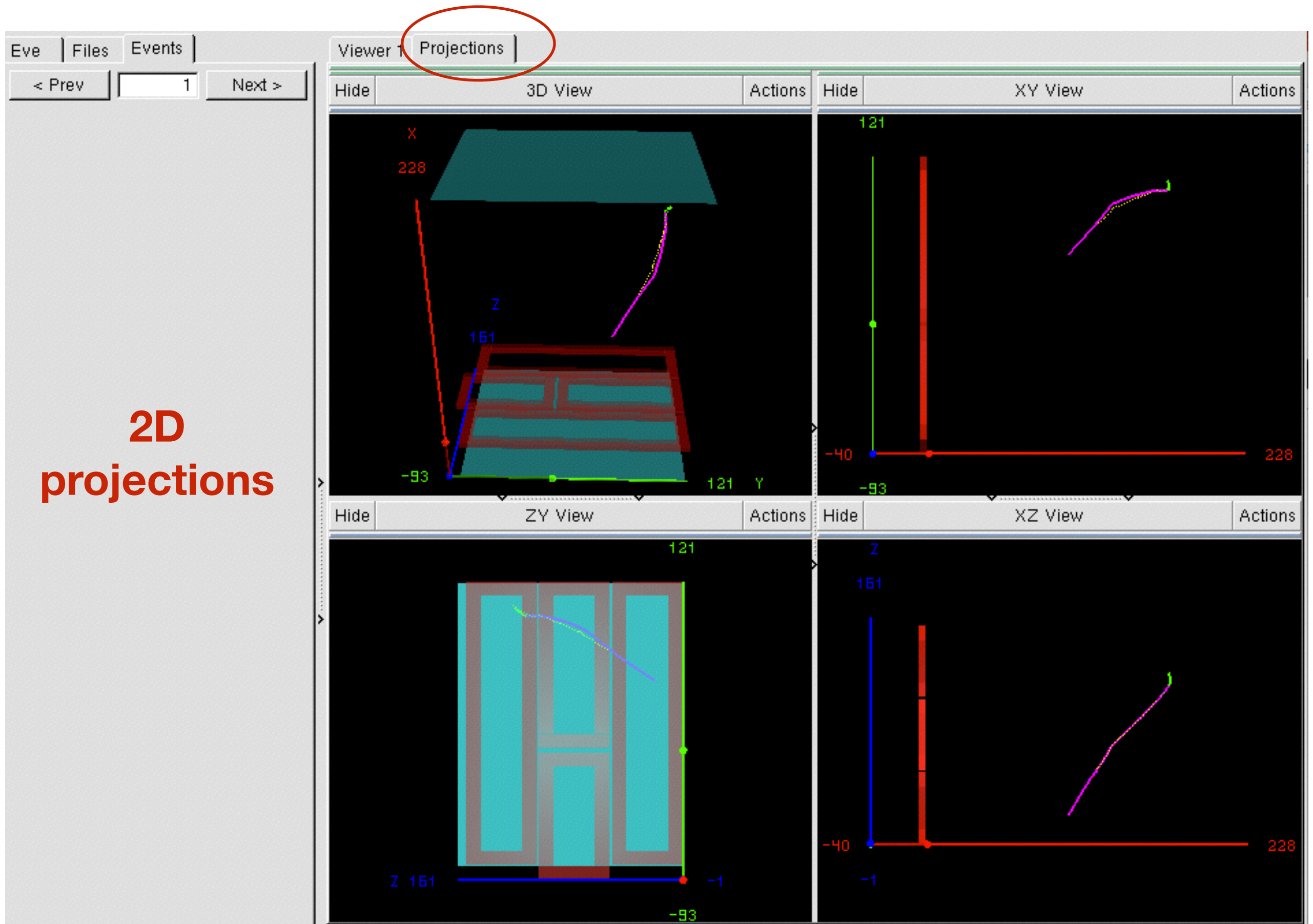
reco tracks  
in dashed  
lines

hovering  
over each  
track will  
highlight the  
track in the  
3d display

can rotate, move,  
zoom in, zoom out,

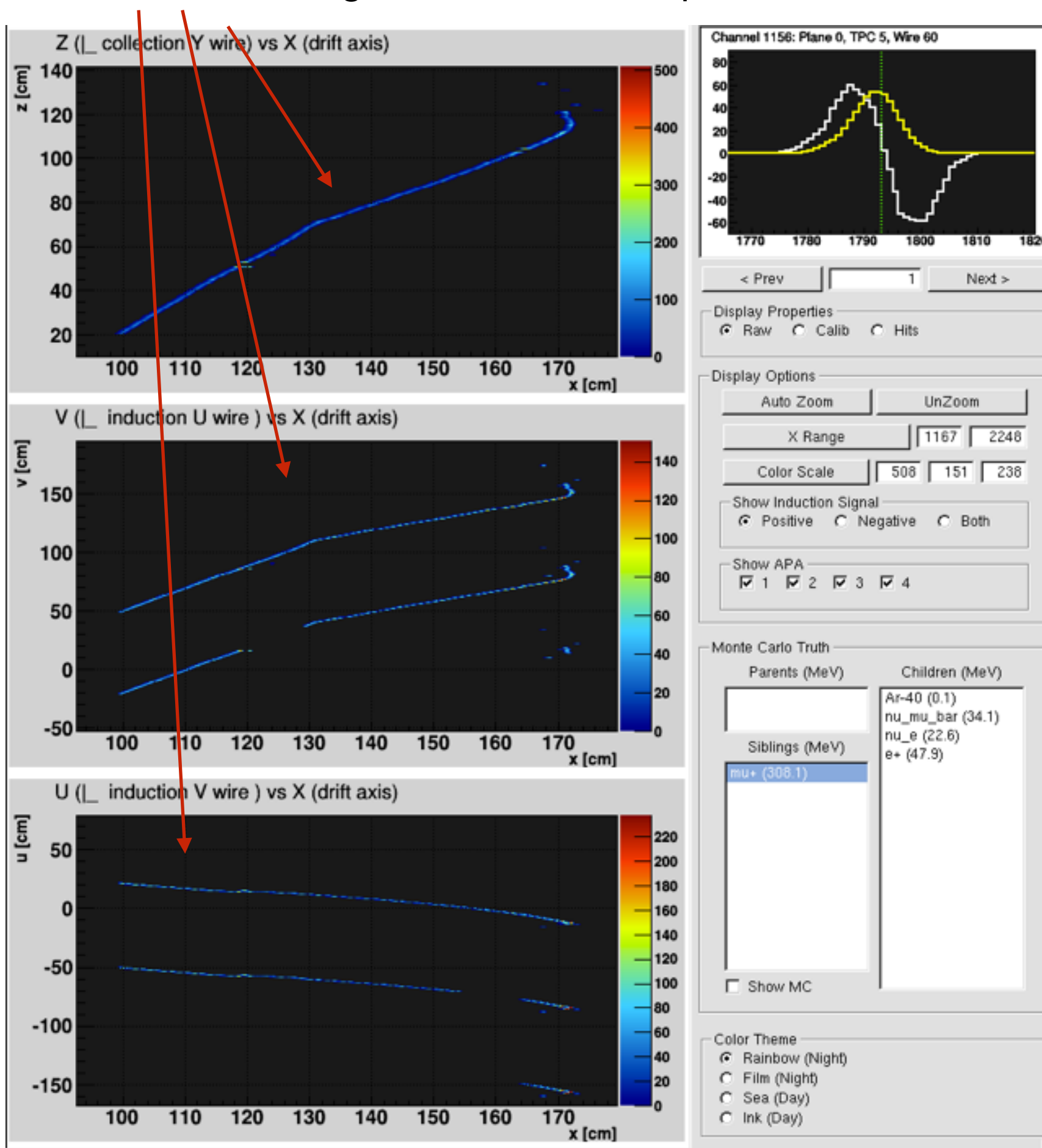
The image shows a software interface for visualizing particle tracks. On the left is a 'Tree' panel with a hierarchical view of the data. It includes folders for 'WindowManager', 'Viewers', 'Scenes', and 'Event'. Under 'Event', there are two main categories: 'Event 1: MC Tracks' and 'Event 1: Reco Tracks'. 'MC Tracks' contains '1: mu+' (pink) and '44: e+' (green). 'Reco Tracks' contains 'track 0' (pink), 'track 1' (green), and 'track 2' (yellow). Below the tree is a 'Style' section with a 'Scenes [TEveSceneList]' dropdown and 'TEveElement' settings where 'Self' and 'Children' are both checked. On the right is a 'Viewer 1' window with a 'Projections' tab. It displays a 3D scene with a dark background. A large teal rectangular volume represents the detector. A red wireframe structure is visible within it. Two tracks are shown: a solid pink line (MC track) and a dashed pink line (reco track) that closely follow each other. A green dashed line is also visible. Coordinate axes are shown: a red 'x' axis with value 228, a blue 'z' axis with value 151, and a green 'y' axis with value 121. Other values like -40, -1, and -93 are also present near the axes. Red arrows point from the text labels to specific elements in the interface: 'event navigation' points to the 'Events' tab; '2D projections (next slide)' points to the 'Projections' tab; 'MC tracks in solid lines' points to the '1: mu+' track in the tree; 'reco tracks in dashed lines' points to the 'track 0' track in the tree; 'hovering over each track will highlight the track in the 3d display' points to the 'track 0' track in the tree; and 'can rotate, move, zoom in, zoom out,' points to the 3D visualization area.

# 2D projections





## Main window: signals on the 3 wire planes



## 2D Event Display

wire signal  
(after click on a wire)

event navigation

toggle raw/calib/hits  
in the main window

some more display  
controls

turn on/off APAs

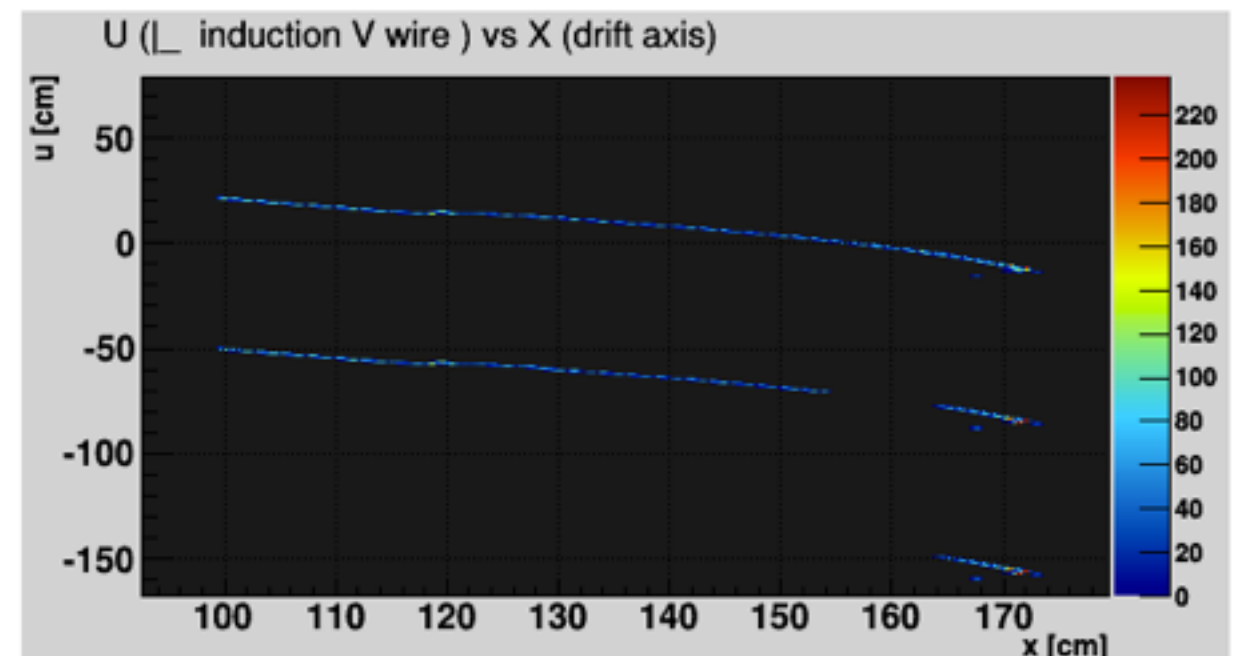
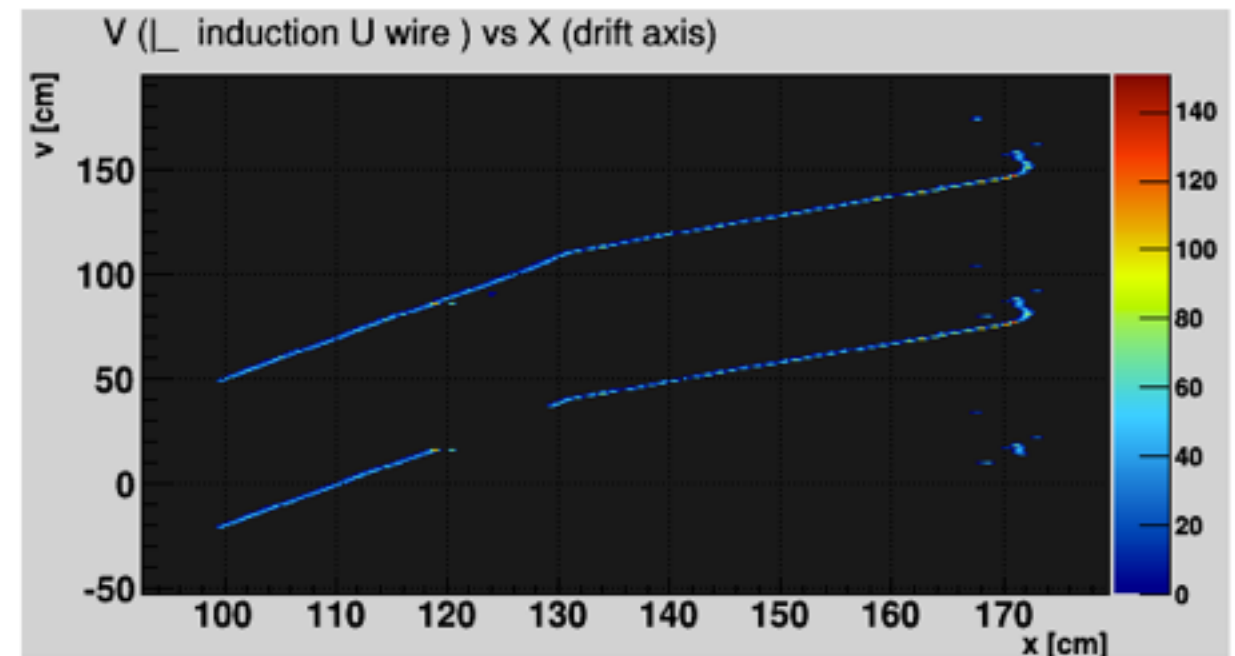
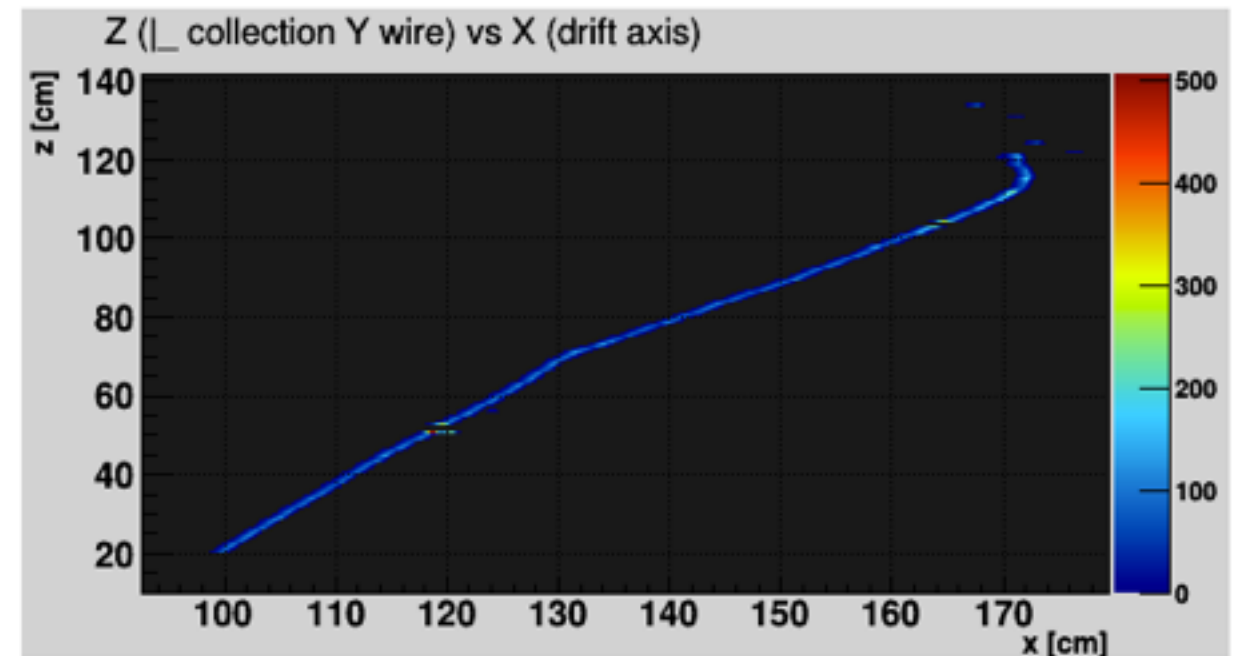
MC track display  
control

change color scheme



# Main Window

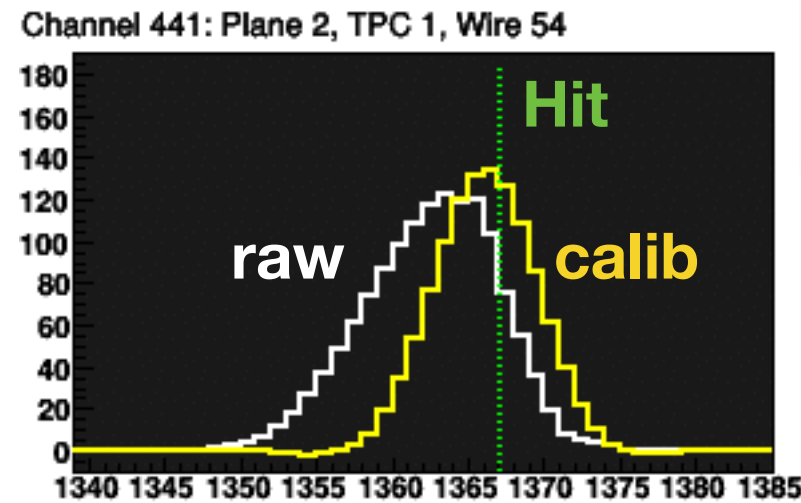
- The 3 planes are (from top to bottom)
  - Y (collection)
  - U (induction)
  - V (induction)
- X-axis is the common drift distance (cm) in x direction
  - tdc converted to cm based on drift velocity calculation
  - zoom in/out on x-axis will simultaneously zoom all 3 figures
- Z-axis is the distance (cm) perpendicular to the wires
  - calculated based on wire pitch and orientation
- Color scale/theme can be set from the right control panel



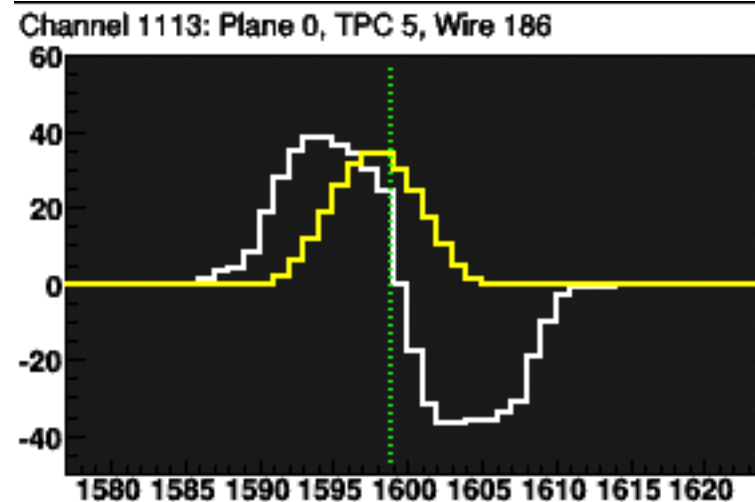
# Wire Signal Window

- Click a wire in the main window will show its signal in the wire signal window
  - Raw signal (white)
  - Calibrated signal (yellow)
  - Hits found (green line)
- It will also show the channel#, wire#, tpc#, etc.

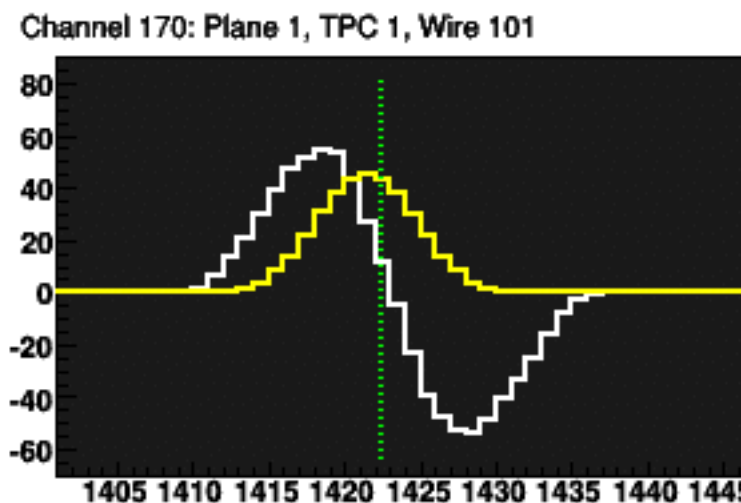
## Collection Plane (Y)



## Induction Plane (U)



## Induction Plane (V)



## Signal Processing

Raw Signal

CalWire

Calibrated Signal

HitFinder

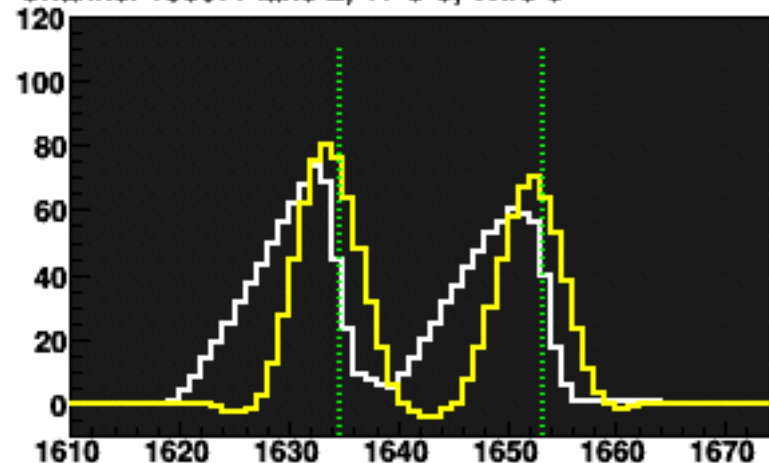
Hits

Hit time  
Hit charge

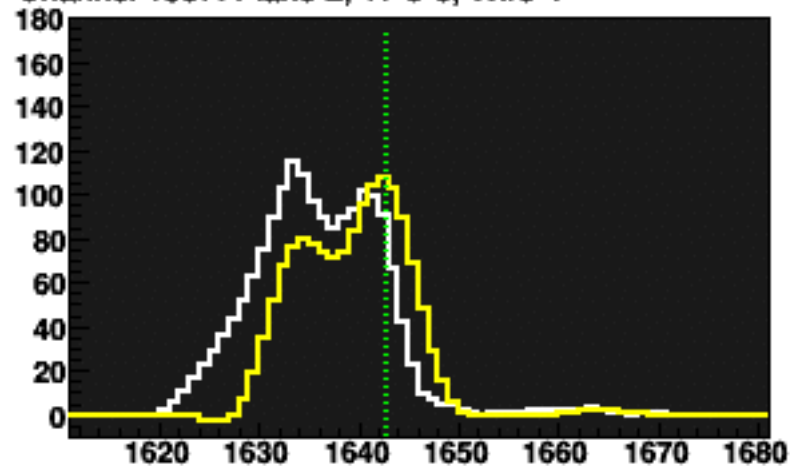
# More Examples of Wire Signals

## Collection Plane

Channel 1389: Plane 2, TPC 5, Wire 6

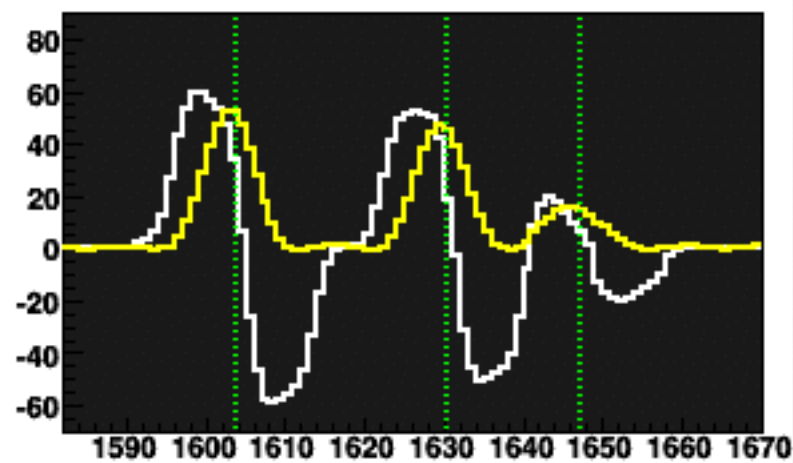


Channel 1387: Plane 2, TPC 5, Wire 4

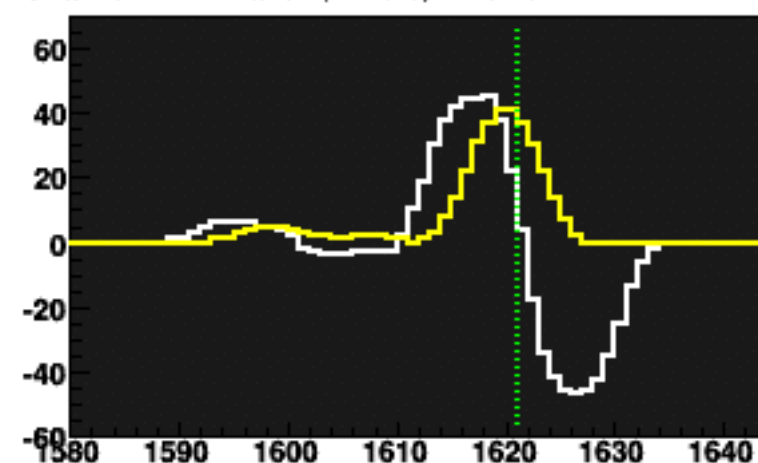


## Induction Plane

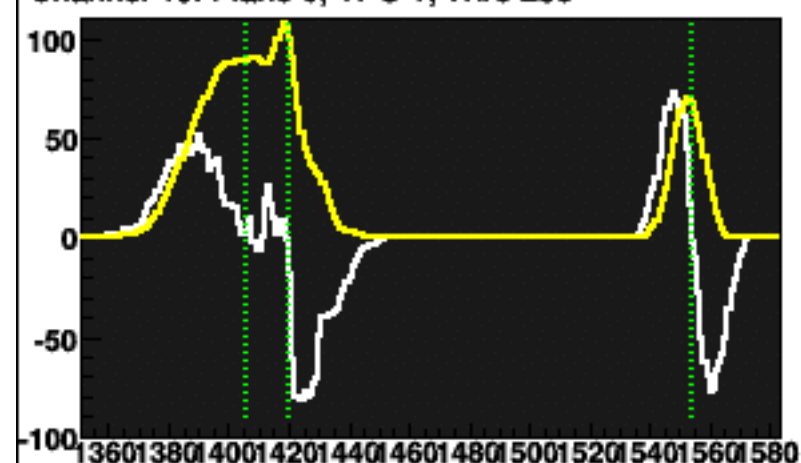
Channel 1179: Plane 1, TPC 5, Wire 114



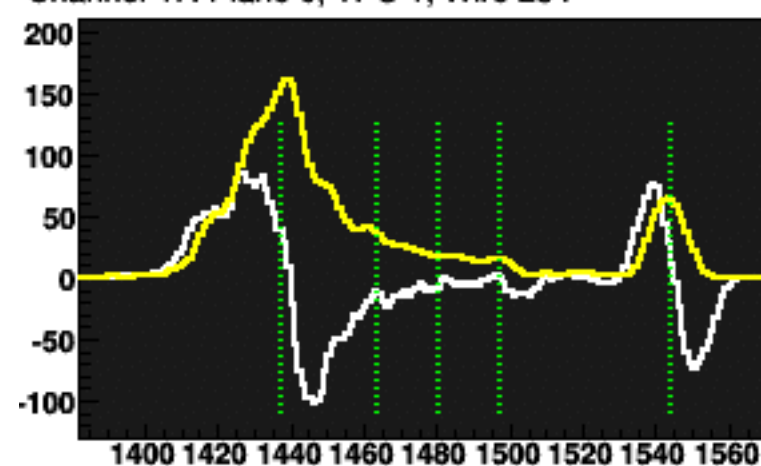
Channel 1114: Plane 0, TPC 5, Wire 187



Channel 48: Plane 0, TPC 1, Wire 255

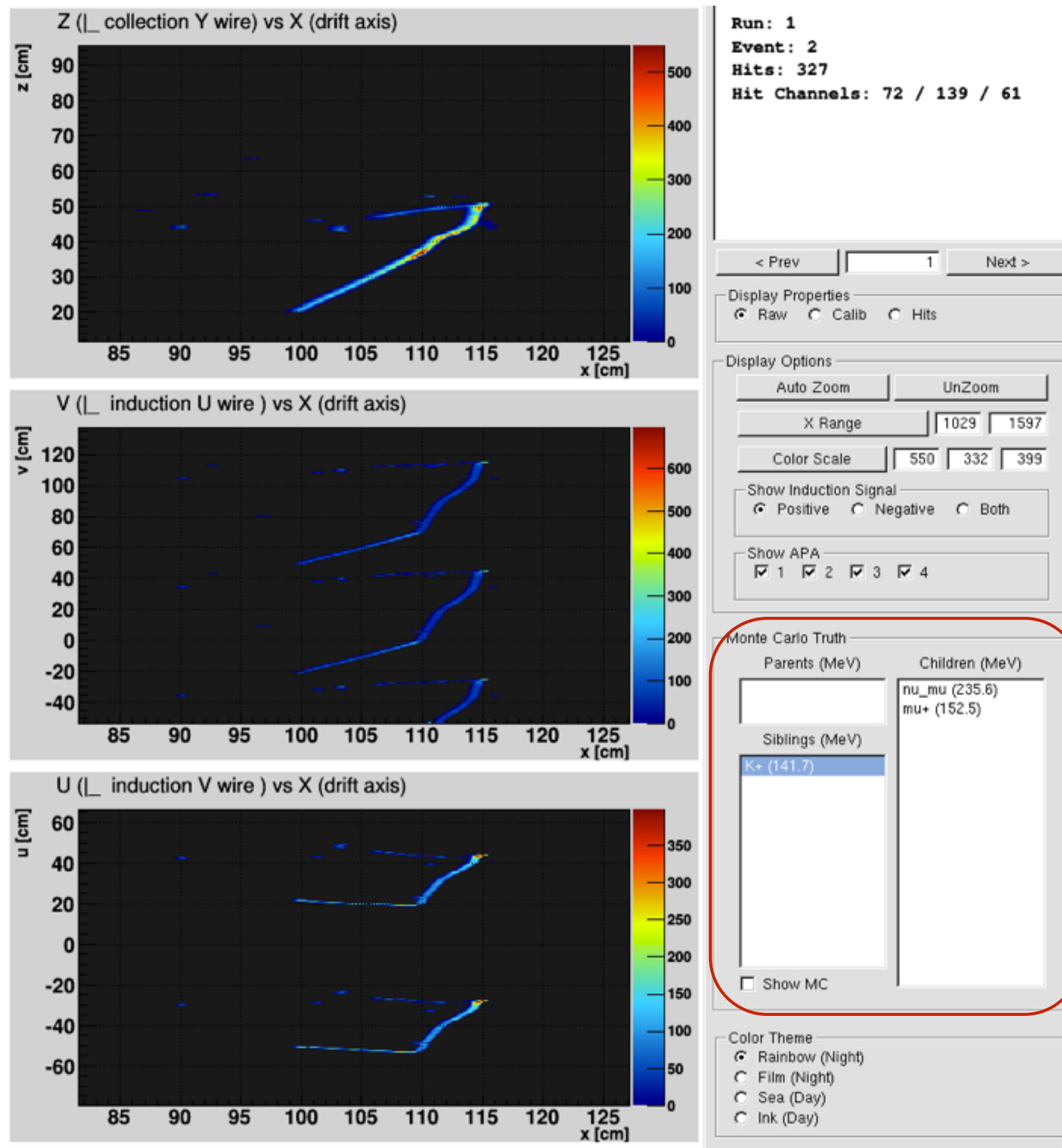


Channel 47: Plane 0, TPC 1, Wire 254

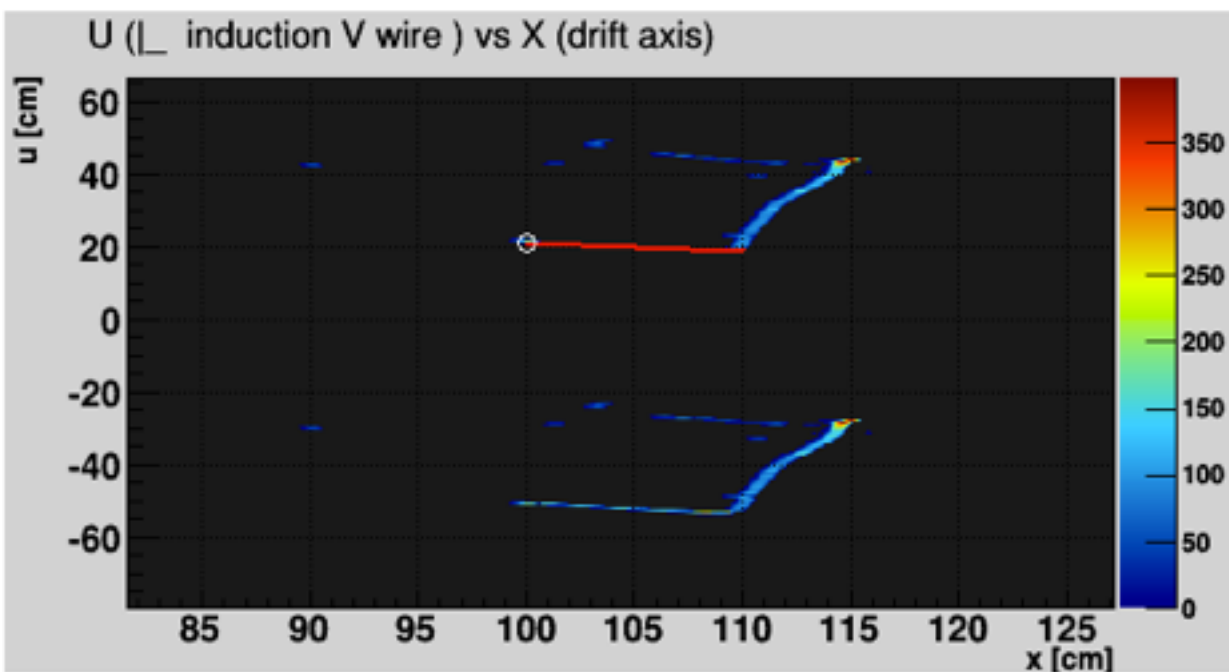
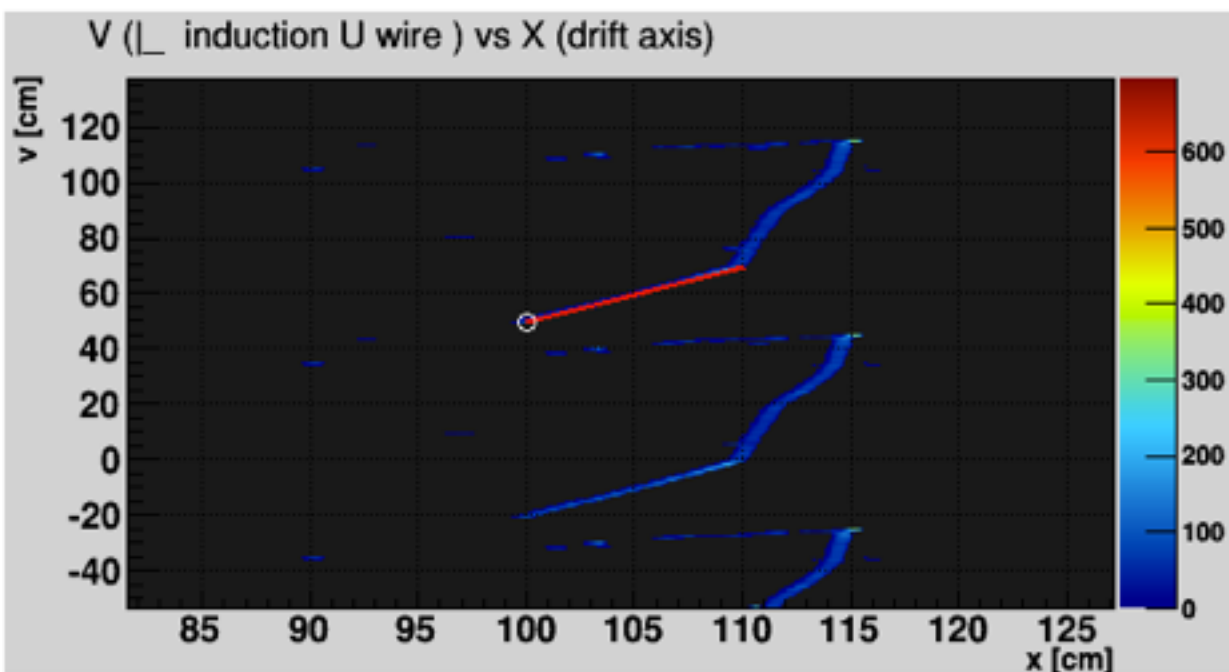
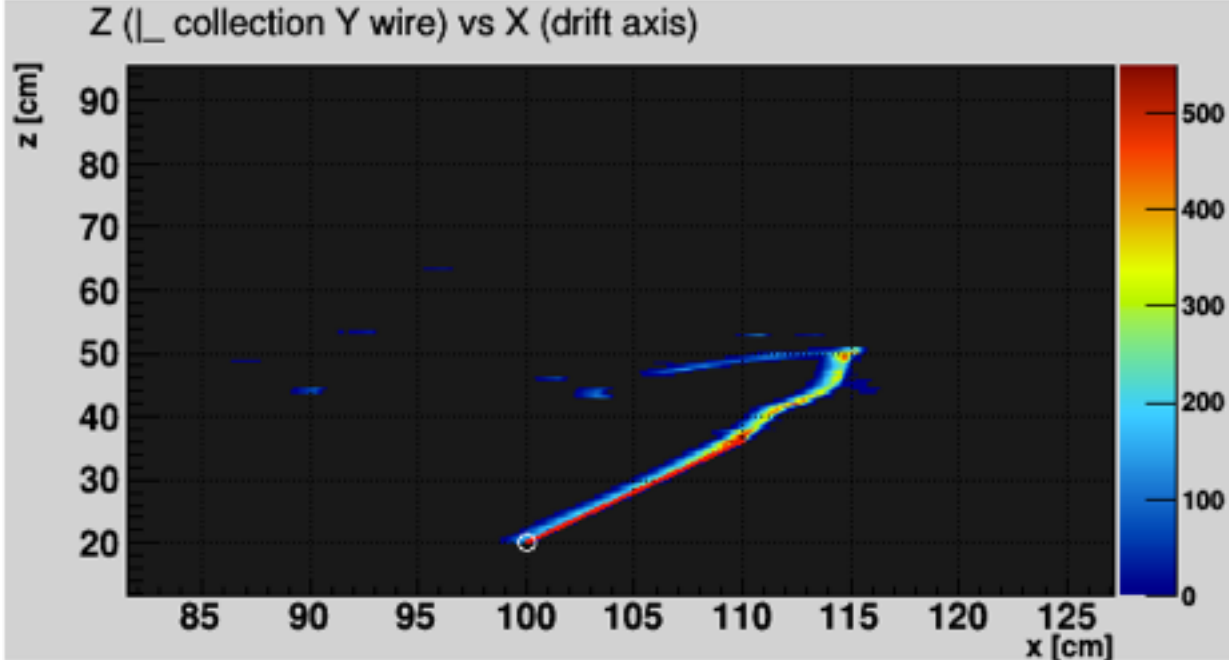


# MC Tracks

- This panel controls the navigation of MC tracks
- click the tracks in the parents/ children listbox to navigate
- current only show a straight line from start to end in each plane.  
(Xiaoyue is working on displaying the whole trajectory)







Run: 1  
Event: 2  
Hits: 327  
Hit Channels: 72 / 139 / 61

< Prev 1 Next >

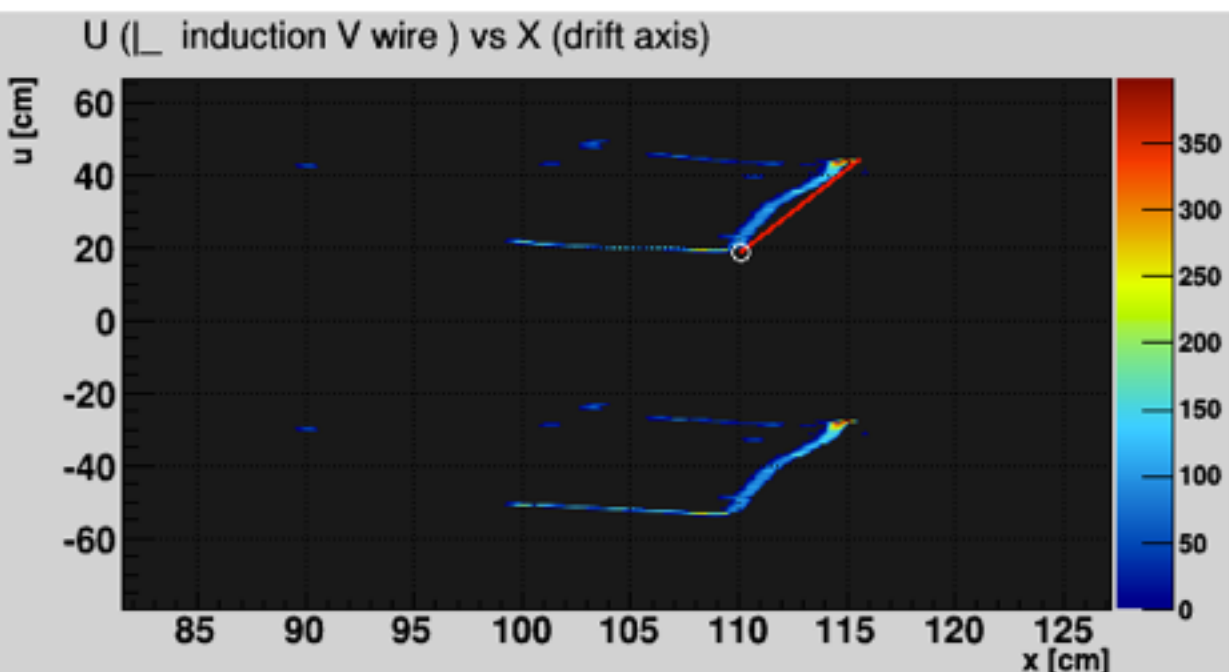
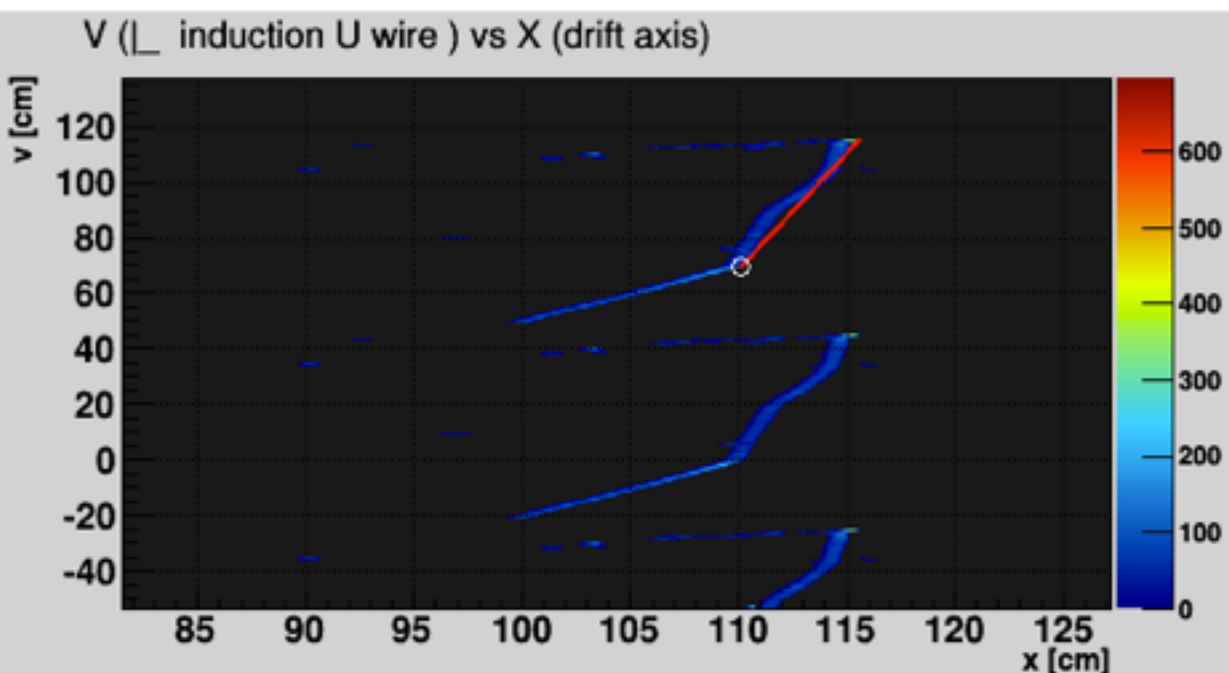
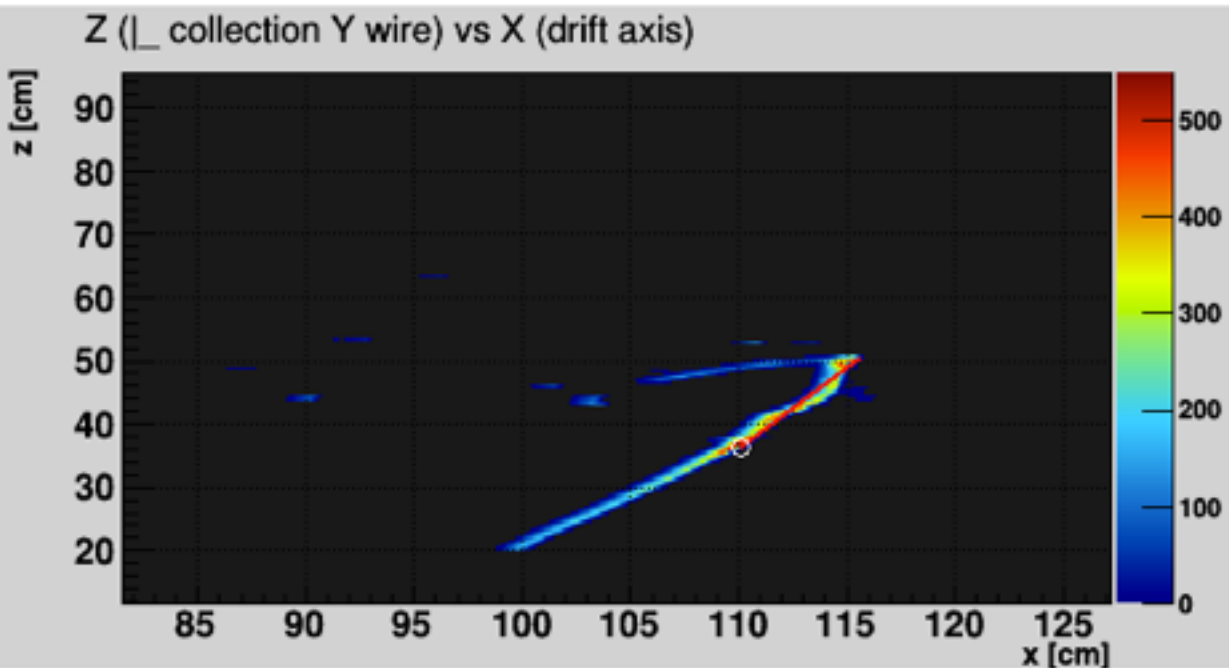
Display Properties  
☒ Raw ☐ Calib ☐ Hits

Display Options  
 Auto Zoom UnZoom  
 X Range 1029 1597  
 Color Scale 550 332 399  
 Show Induction Signal  
☒ Positive ☐ Negative ☐ Both  
 Show APA  
☒ 1 ☒ 2 ☒ 3 ☒ 4

Monte Carlo Truth  
 Parents (MeV)  
 Children (MeV)  
 Siblings (MeV)  
 K+ (141.7)  
 nu\_mu (235.6)  
 mu+ (152.5)  
☒ Show MC

Color Theme  
☒ Rainbow (Night)  
☐ Film (Night)  
☐ Sea (Day)  
☐ Ink (Day)

Example:  
 $K^+ \rightarrow \mu^+ \rightarrow e^+$



Run: 1  
Event: 2  
Hits: 327  
Hit Channels: 72 / 139 / 61

< Prev 1 Next >

Display Properties  
☒ Raw ☐ Calib ☐ Hits

Display Options  
 Auto Zoom UnZoom  
 X Range 1029 1597  
 Color Scale 550 332 399  
 Show Induction Signal  
☒ Positive ☐ Negative ☐ Both  
 Show APA  
☒ 1 ☒ 2 ☒ 3 ☒ 4

Monte Carlo Truth

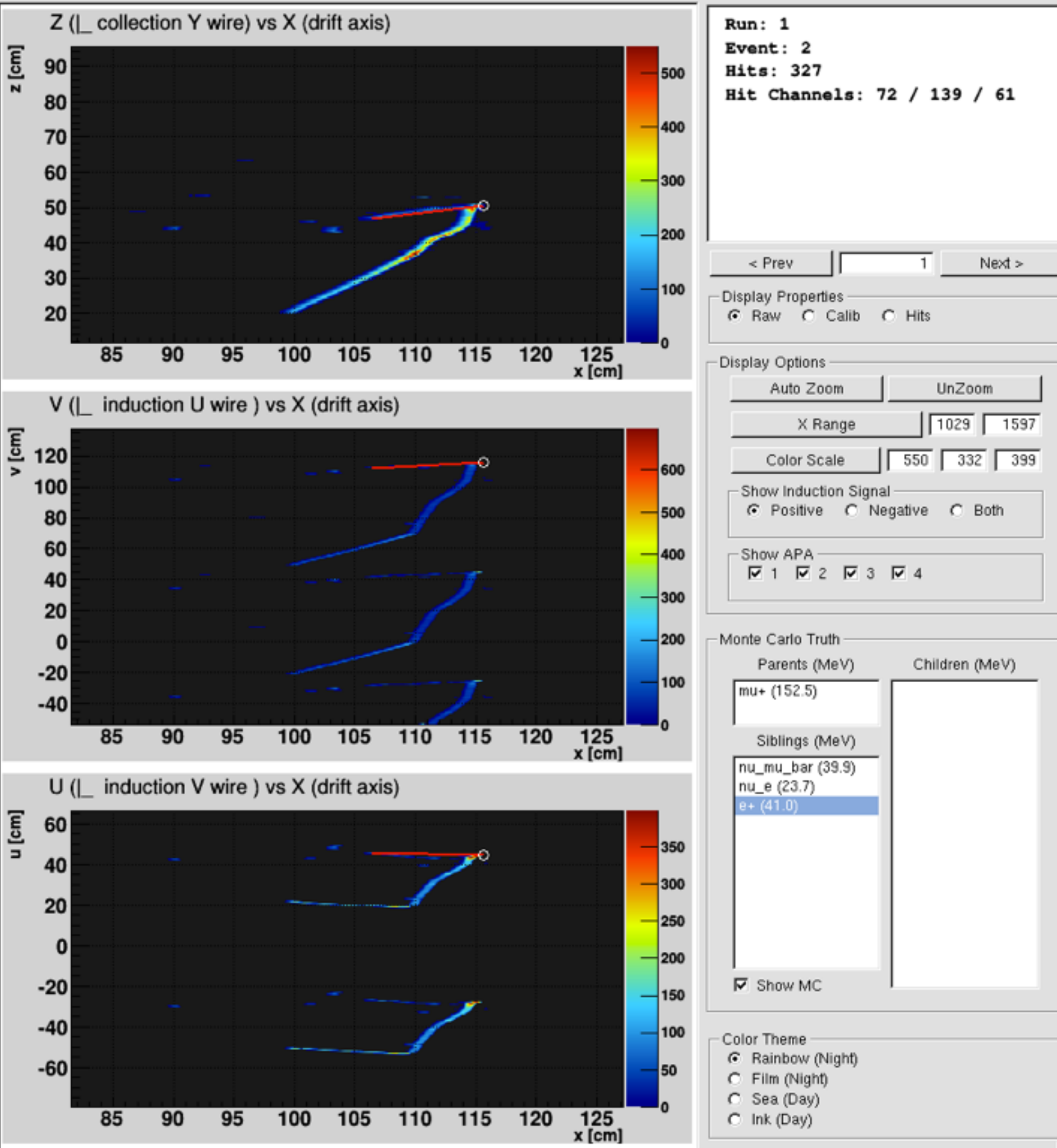
Parents (MeV)	Children (MeV)
K+ (141.7)	nu_mu_bar (39.9)
	nu_e (23.7)
	e+ (41.0)
Siblings (MeV)	
nu_mu (235.6)	
mu+ (152.5)	

☒ Show MC

Color Theme  
☒ Rainbow (Night)  
☐ Film (Night)  
☐ Sea (Day)  
☐ Ink (Day)

Example:  
 $K^+ \rightarrow \text{mu}^+ \rightarrow e^+$





Example:  
 $K^+ \rightarrow \mu^+ \rightarrow e^+$

# Planned Future Improvements

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- Show the true trajectories (instead of start-end lines) and the reco tracks in the 2D display (already so in the 3D display)
- Add photon detector information
- Add muon paddle information
- Optimize the size/speed
- Many other little touches ...
- Any feedback/requests will be welcome